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SOIL-RELEASE FINISHES FOR POTENTIAL USE IN THE WHITE
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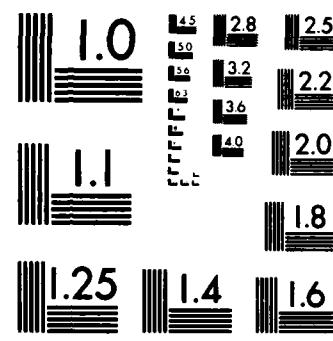
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Southeastern Massachusetts University, under contract to the Navy Clothing and Textile Research Facility (NCTR), performed a comprehensive study to determine whether a soil-release finish was commercially available that could effectively assist in the control of soil redeposition during laundering and in the removal of such stains as black shoe polish, dirty motor oil, fruit juices, and lipstick from the Certified Navy Twill (CNT), 100%		

texturized polyester uniforms. Because of the type of stains that were used in this study, much work was required in developing application procedures that would provide a high degree of reproducibility. Results of the study demonstrated that there were three finishes on the market that could meet the Navy's requirements - Zelcon 4951 (DuPont), FC-258 (3M Co.), and Milease HPA (ICI). The finishes are non-toxic and can withstand multiple home and shipboard launderings (25 minimum) and drycleanings (10 minimum). These finishes also have no adverse effect on the physical, chemical, and colorfastness properties of the treated fabric. A new soil-release test procedure and evaluation method was developed for use in the CNT specification to assure that material procured in the future for fabrication into garments will meet the Navy's soil-release performance requirements. (U)

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SOIL-RELEASE FINISHES FOR POTENTIAL USE IN THE WHITE CERTIFIED NAVY TWILL UNIFORMS

INTRODUCTION

Southeastern Massachusetts University, under Contract No. N00140-82-R-R-CQ45 with the Navy Clothing and Textile Research Facility (NCTR), performed a comprehensive study, which demonstrated that there exists commercially available soil-release finishes that can effectively assist in the removal of such stains as shoe polish, dirty motor oil, fruit juices, and lipstick from the white, 100% texturized polyester, 7.0 oz/yd², Certified Navy Twill (CNT) used in the manufacture of Navy Service Dress White and Summer White Uniforms. The objective of this investigation was to develop a durable soil-release finish for use on the CNT uniforms. This study was necessary because of problems being encountered with stain removal and soil redeposition during laundering of the garments.

A thorough evaluation was made of the state-of-the-art technology of commercially available finishes having different chemical, physical, and surface chemical characteristics. This study showed that some commercial finishes possess the desired characteristics. The best soil-release finishes found in this study were Zelcon 4951 (DuPont), FC-258 (3M Co.), and Milease HPA (ICI), when applied at 4% of weight of fabric) under pressure and following each manufacturer's recommended application conditions.

The selected finishes are non-toxic and durable for multiple home and shipboard launderings (25 minimum) and drycleanings (10 minimum). They are commercially available and can be applied to piece goods by many textile dyeing and finishing plants. These finishes greatly increased the release of such stains as dirty motor oil, black shoe polish, lipstick, French dressing and fruit juices compared with non-soil-release-treated fabrics. In most cases, the selected soil-release finishes removed more than 90% of the staining medium applied to the fabric after one laundering. Some difficulties, however, were experienced in removing the last traces of dye found in certain stains like lipstick and black shoe polish. The selected soil-release finishes had no adverse effect on the physical, chemical, and colorfastness properties of the treated fabric. Application of a soil-release finish resulted in the fabric's being smoother and more pleasant to the touch than the regular untreated fabric.

To assure that CNT material procured in the future for fabrication into garments will meet the Navy's soil-release performance requirements, it was necessary to develop a new soil-release test procedure and evaluation method, which will be included in the CNT material specification.

This report discusses the findings of the study, details the methods used to obtain these findings, and describes the new soil-release test and evaluation procedure.

BACKGROUND

In the days when cotton was king and permanent press finishes were a thing of the future, people had few problems in removing various soils from garments by simple laundering. With the advent of permanent press treatments, the necessary change from 100% cotton to polyester/cotton blends rich in polyester, and garments now being constructed from 100% polyester, soil removal has become a problem. Fabrics containing polyester tend to retain soil. In addition, the soil and stains removed from fabrics during laundering tend to redeposit on the garment during the wash cycle so that white items quickly turn gray and colored items become dull.

Consequently, a good soil-release finish must perform two functions: the release of the soil itself and the prevention of soil redeposition. These terms can be defined as follows.

Soil-Release - The ability of a fabric to release various types of soils upon washing or dry cleaning.

Soil Redeposition - The gradual pickup by fabric of soil suspended in wash water, which leads to graying of the fabric.

Soil Resistance - The ability of the fabric to resist soiling or staining.

Polyester fabrics become soiled, because they are inherently oleophilic and hydrophobic: the polyester fiber has great affinity for oils and greases but little for water. Oily soils thus tend to cling to the surfaces of polyester fibers and embed particles of soil. Moreover, the hydrophobic nature of the fiber prevents penetration of the detergent solution during laundering to solubilize and disperse the oily stains. To remedy this problem, soil-release finishes for 100% polyester fabrics work by making these hydrophobic fabrics hydrophilic (water loving) in nature, permitting relatively easy removal of stains and soil and also reducing soil redeposition.

The Navy now uses 100% texturized polyester, 7.0 oz/yd² twill in the manufacture of Service Dress White and Summer White uniforms for both male and female enlisted and officer personnel. While these uniforms offer improved appearance and wrinkle-resistant features compared with the previous white uniforms, their polyester construction results in stain removal and soil redeposition problems. Consequently, a soil-release finish is required that can effectively remove black shoe polish, dirty motor oil, lipstick, and other oil-based stains. Ideally, the treatment should withstand multiple home and shipboard launderings (25 minimum) and dry cleanings (10 minimum), and not affect the durability of the material's physical characteristics.

SELECTION OF STAINING MATERIALS

The five stains used throughout this study were as follows:

1. Salad Dressing -	Kraft French Dressing
2. Grape Juice -	Welch's Grape Juice
3. Motor Oil -	Arco Graphite Multi-Grade Motor Oil (SAE 10W40)
4. Lipstick -	Cover Girl Lipstick (Red)
5. Shoe Polish -	Kiwi Shoe Polish (Black)

These five were judged to represent most generally the types of stains that the uniforms would be subjected to. Although the use of French dressing, grape juice, lipstick, and shoe polish are self-explanatory, the use of graphite motor oil was an attempt to simulate burnt or dirty motor oil.

We first tried this simulation by adding graphite flakes to a clean commercial motor oil. Reproducibility problems, however, were encountered when the suggested mixture of 15% graphite flakes in motor oil was used, because the graphite flakes tended to settle in the oil and could not be stirred successfully back into suspension. Also, the fabric acted as a filter for the graphite flakes, forming an inner circle of graphite flakes with a halo of pure oil. After much experimentation, the best simulation for burnt or used motor oil was the commercially available Arco Graphite Multi-Grade Motor Oil (SAE 10W40) because of its ability to retain its homogeneity. This was found to be a formidable stain for removal from the untreated fabric as well as a stain that could differentiate between types and levels of soil-release finishes in a reproducible manner.

APPLICATION OF STAINING MATERIALS TO FABRIC

Liquid Stains

For the application of the liquid stains (salad dressing, grape juice, and motor oil), the AATCC Test Method 130-1981 was followed, with three drops of motor oil used in place of five drops of Nujol. No problems were encountered with this procedure.

Solid Stains

A new method, which had to be developed to apply the solid stains (shoe polish and lipstick), involved using the AATCC Crockmeter. Fifty milligrams of solid stain were placed on a thin plastic sheet approximately the diameter of the crockmeter peg. A square of standard crockmeter cloth was then placed over the plastic disk containing the solid stain. A square of glassine paper was placed over the cloth, and a 2-kilogram weight was placed directly over the glassine paper and allowed to sit undisturbed for 60 seconds. The weight

was then removed, the glassine paper discarded, and the sandwich of the plastic disk, solid stain, and crockmeter cloth was placed undisturbed on the crockmeter peg with the plastic disk touching the peg. The standard clamp was used to secure the crockmeter cloth to the peg. A piece of fine-grade emery paper by NOBOND was taped, face up, to the crockmeter base where the fabric was placed to keep the fabric from moving during stroking. The polyester fabric was placed face up with the warp direction of the fabric parallel to the direction of the crockmeter. The fabric was first stroked three times and then moved over 1 inch and stroked one time. The fabric was moved over again and stroked another time. Additional one stroke stains were made producing a series of lighter and lighter stains on the fabric. Therefore, seven stains, including the first stain made by three strokes, were used for evaluation purposes.

Standard testing conditions were used to obtain optimum reproducibility. The stained medium should be stored under these conditions and checked from time to time to be sure it does not dry out, and it should be replaced if its texture changes.

INVESTIGATION OF COMMERCIAL SOIL-RELEASE FINISHES

A thorough search was made of all commercially available soil-release finishes. Twenty-seven chemical companies marketing soil-release agents were contacted to determine the products they offer for 100% polyester fabrics. The various products were classified by chemical types as follows:

1. Fluorochemicals
2. Acrylics
3. Polyesters
4. Silicones

Manufacturers' recommended application techniques were used as well as variations of those procedures. Five concentration levels of various chemicals were used in each treatment, and recommended application parameters, such as time, temperature, pH, and other recommended additives were used in the initial screening. The fluorochemicals, silicones, and acrylics either did not give the desired soil-release properties or were not durable after launderings. The best soil-release finishes were the polyester types, which were primarily developed (with some exceptions) for use on 100% polyester fabrics. Of these, the best were Zelcon 4951 (DuPont), Scotch-Release Brand FC-258 (3M Co.), and Milease HPA (ICI). These soil-release treatments, in particular, greatly improved the release of shoe polish, lipstick, and motor oil stains.

Table I presents the results of fabrics treated under pressure with the three polyester finishes and laundered at 140°F with 140g of AATCC Detergent. After the fabrics were stained, laundered once, and rated, they were laundered nine more times, stained, laundered one additional time, and tested again.

TABLE I

SOIL-RELEASE RATINGS OF FABRIC TREATED UNDER PRESSURE WITH
ZELCON 4951, FC-258, AND MILLESE HPA AFTER ONE AND TEN HOME LAUNDERINGS

Stain	Salad Dressing			Grape Juice			Motor Oil			Lipstick			Shoe Polish		
	Untreated	Zelcon 4951	FC-258	Untreated	Zelcon 4951	FC-258	Untreated	Zelcon 4951	FC-258	Untreated	Zelcon 4951	FC-258	Untreated	Zelcon 4951	FC-258
	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering	Laundering
Salad Dressing	10	10	10	1	1	1	1	1	1	1	1	1	1	1	1
Grape Juice				10	10	10	10	10	10	10	10	10	10	10	10
Motor Oil				1	1	1	1	1	1	1	1	1	1	1	1
Lipstick															
Shoe Polish															
Laundering															
Untreated	5	5	5	5	5	5	2	2	2	2	2	2	2	2	2
Zelcon 4951	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4
FC-258	5	5	5	5	5	5	4	4	4	3	3	3	3	3	3
Milease HPA	5	5	5	5	5	5	4	4	4	2-3	2-3	2-3	2-3	2-3	2-3

5 = Excellent (100% removed), Equal to AATCC Gray Scale, Step 5

4 = Good (75% removed), Equal to AATCC Gray Scale, Step 4

3 = Fair (50% removed); Equal to AATCC Gray Scale, Step 3

2 = Poor (25% removed). Equal to ATCC Gray Scale, Step 2

2 = 100% (25% removed); Equal to AACG Gray Scale; Step 1 = Very Poor (0% removed). Equal to ATCC Gray Scale. Step 1

Half stents such as 2-3 (26 - 49%). are used if needed.

TABLE II
SOIL-RELEASE RATINGS OF VARIOUS SOIL RELEASE TREATMENTS APPLIED ATMOSPHERICALLY (A)
AND UNDER PRESSURE (B) AFTER ONE LAUNDERING (140° F/140G AATCC DETERGENT)

		Strain									
		Salad Dressing		Grape Juice		Motor Oil		Lipstick		Shoe Polish	
		A	B	A	B	A	B	A	B	A	B
Zelcon 4951	5	5	5	5	5	3-4	4	2-3	4	3	4
FC-258	5	5	5	5	5	2	4	3	3	2	3
Milease HPA	5	5	5	5	5	3	4	2-3	2-3	2	2-3

5 = Excellent (100% removed), Equal to AATCC Gray Scale, Step 5

4 = Good (75% removed), Equal to AATCC Gray Scale, Step 4

3 = Fair (50% removed), Equal to AATCC Gray Scale, Step 3

2 = Poor (25% removed), Equal to AATCC Gray Scale, Step 2

1 = Very Poor (0% removed), Equal to AATCC Gray Scale, Step 1

Half steps, such as 2-3 (26 - 49%), are used if needed.

INVESTIGATION OF LAUNDERING CONDITIONS

Detergent

Most of the laboratory launderings were performed in an automatic washer with AATCC Standard Detergent WOB (without bleach) for reproducibility purposes. Because of time and resource limitations, we studied only a few of the wide variety of detergent formulations on the market. Table III shows a comparison of Navy, Dash and AATCC detergents on the soil-release properties of untreated fabric laundered (140°F) with various concentrations of detergent. Dash, a commercially available product, was found to provide similar results as the AATCC standard detergent. As can be seen in Table III, the best soil-release results, however, were obtained with the P-D-245C, Type II detergent commonly used aboard ship (not commercially available).

As expected, the more detergent in the wash water, the better the soil-release results. With the Navy detergent, the best results were obtained with a minimum of 70g of detergent in the washing machine, while with Dash and the AATCC detergent, a minimum of 140g gave the best results.

Wash Water Temperature

The effect of the wash water temperature on fabric cleanability was studied at temperatures of 80°F, 100°F, 140°F and 160°F. Results indicate that, to obtain maximum benefit from the soil-release treatment, the wash water temperature should be 140°F (60°C) or higher.

Prespotting Studies

The use of prespotting laundry products can be very helpful in aiding the release of stains in laundering both on untreated and soil-release-treated fabrics. The prespotting products work better on soil-release-treated fabric than on untreated fabric and do not have an adverse effect on the durability of the soil-release finish.

Eight prespotting products were used to try to remove four stains on untreated fabric. Manufacturers' directions were followed for each product. For products which called first for rubbing and wiping off the stains as much as possible, the process was repeated until no more of the stain could be removed by hand. At that point, the sample was laundered at 140°F, regular cycle, using AATCC detergent (140g).

TABLE III

SOIL-RELEASE RATINGS OF UNTREATED FABRIC LAUNDERED ONCE (140° F)
WITH VARIOUS DETERGENTS AND CONCENTRATIONS AT 35g, 70g, AND 140g

Detergent	Salad Dressing			Grape Juice			Motor Oil			Lipstick			Shoe Polish		
	35g	70g	140g	35g	70g	140g	35g	70g	140g	35g	70g	140g	35g	70g	140g
NAVY	5	5	5	5	5	5	2	3	3	3	4	4	3	4	4
DASH	5	5	5	5	5	5	1	1	1	2	2	2	2	2	2
AATCC	5	5	5	5	5	5	1	1	1	2	2	2	2	2	2

5 = Excellent (100% removed), Equal to AATCC Gray Scale, Step 5

4 = Good (75% removed), Equal to AATCC Gray Scale, Step 4

3 = Fair (50% removed), Equal to AATCC Gray Scale, Step 3

2 = Poor (25% removed), Equal to AATCC Gray Scale, Step 2

1 = Very Poor (0% removed), Equal to AATCC Gray Scale, Step 1

The results are listed in Table IV. As can be seen, the use of certain prespotting chemicals can be very helpful in aiding the release of stains during laundering. The use of a detergent like Wisk for prespotting was particularly effective in the removal of lipstick and shoe polish stains.

Durability of the Soil-Release Finish

Home Launderings. Durability studies of fabric treated with a soil-release finish applied under pressure show that the finish remains on the fabric for at least 50 home launderings (140°F). Motor oil, lipstick, juice, and salad dressing stains are still readily released up to 50 launderings. Although the release of the shoe polish stain after 10 launderings is significantly reduced, it is still better than fabric without the soil-release finish.

Some studies were conducted to determine if the finish was still effective in removing stains that were re-applied in the same area of the fabric after the original stains had been laundered. Results indicated that the removal of repeated stains in the same area is not a problem since the same soil-release rating was recorded initially and after re-staining.

Shipboard Launderings. The soil-release-treated fabric was also tested for durability to shipboard laundering (160°F) with the standard shipboard laundering formulations and equipment. The results are shown in Table V. The fabric was evaluated for soil-release properties after 1, 5, 15, 20, 25, 30, 35, 40, 45, and 50 launderings. The treated fabric showed excellent soil-release properties with all five stains up to 25 launderings. These results were significantly better than those obtained on the untreated fabric. One performance property noticed after the shipboard launderings was the treated fabric's excellent anti-soil redeposition properties, which resulted in its being considerably whiter than the untreated control fabric subjected to the same number of launderings.

TABLE IV
SOIL-RELEASE RATINGS OF PRESPOTTING STUDIES (140° F/140g AATCC DETERGENT)

Product	French Dressing	Motor Oil	Lipstick	Shoe Polish
Goop (Crittas Industries, Inc.)	5	4	4	5
Shout (S.C. Johnson & Sons, Inc.)	5	2	2-3	1-2
Wisk (The Metalife Company)	5	3	4-5	4-5
All-Purpose Cleaner (K-Mart Corporation)	5	2-3	4-5	5
Spray N' Wash (Morton Norwich Products, Inc.)	5	4	5	2
Spritz (Airwick Industries, Inc.)	5	3-4	4-5	5
Proforce (Airwick Industries, Inc.)	5	5	5	5
Spot-Tex (Airwick Industries, Inc.)	5	2	1-2	3-4

5 = Excellent (100% removed), Equal to AATCC Gray Scale, Step 5
 4 = Good (75% removed), Equal to AATCC Gray Scale, Step 4
 3 = Fair (50% removed), Equal to AATCC Gray Scale, Step 3
 2 = Poor (25% removed), Equal to AATCC Gray Scale, Step 2
 1 = Very Poor (0% removed), Equal to AATCC Gray Scale, Step 1

Half steps, such as 2-3 (26 - 49%), are used if needed.

TABLE V

SOIL-RELEASE RATINGS OF TREATED FABRIC USING SHIPBOARD LAUNDERING PROCEDURES (160° F)

No. of Launderings	Salad Dressing	Stain			
		Grape Juice	Motor Oil	Lipstick	Shoe Polish
1	5	5	5	5	5
5	5	5	5	5	5
15	5	5	5	5	5
20	5	5	5	5	-
25	5	5	5	5	5
30	5	-	-	-	4-5
35	5	-	-	-	4-5
40	5	5	5	5	4-5
45	5	5	5	5	4-5
50	5	5	5	5	4-5

5 = Excellent (100% removed), Equal to AATCC Gray Scale, Step 5

4 = Good (75% removed), Equal to AATCC Gray Scale, Step 4

3 = Fair (50% removed), Equal to AATCC Gray Scale, Step 3

2 = Poor (25% removed), Equal to AATCC Gray Scale, Step 2

1 = Very Poor (0% removed), Equal to AATCC Gray Scale, Step 1

Half steps, such as 4-5 (76 - 99%), are used if needed.

Drycleaning. The soil-release-treated fabric does not dryclean as well as the untreated fabric unless the stains are prespotted prior to drycleaning. Prespotting, however, should be normal procedure for professional drycleaning establishments, provided that the drycleaner is made aware of the stain by the customer. If prespotting is not performed, chances are that some types of stains will not be completely removed.

If oil stains are not prespotted, there could be problems with migration of the stain during drycleaning. The residual stains could, however, be removed in the next drycleaning provided, of course, the stains are prespotted at that time. In addition, if stains remain after drycleaning, they can usually be removed if given a home laundering.

Our tests showed that the soil-release finish is durable for at least 10 drycleanings with either perchloroethylene or STODDRARD solvent. In fact, drycleaning with perchloroethylene was found to give better soil-release properties than with STODDRARD solvent.

Slight soil redeposition was noted on some drycleaned fabrics, but this was found to vary from one drycleaner to another. This redeposition probably occurred because either the drycleaning solvent was not clean or the drycleaners did not use a "charged" (water containing) system. A second drycleaning usually removes the redeposition.

SOIL REDEPOSITION

The soil redeposition test provides a means of measuring the degree of soil redeposition which may occur on a fabric during the laundry process. It is designed as a laboratory test and is applicable to any light-colored fabric. The soil-release finishes being investigated are expected to reduce the redeposition of soil during laundering of the white dress uniform fabric. In drycleaning, the soil-release finish tends to scavenge some dirt if dirty drycleaning solvent is used. When subsequently drycleaned in clean solvent, however, the dirt is removed.

Soil redeposition studies were conducted with a modified AATCC Test Method 151-1980 (Soil Redeposition, Resistance to: Launder-Ometer Method). In place of the prepared oil-soiled swatches in the test method, standardized polyester-soil test fabrics, purchased from Testfabric Inc., were used. The method consisted of observing how much soiling of the white uniform fabric occurred during the laundering process by soil removed from a standard soil fabric.

In the initial redeposition studies, the two standard soil fabrics obtained from Testfabrics Inc. (Style 767 Spun Dacron, Soil Test Cloth and Soil Test Cloth WPK-30C Polyester) were not effective in differentiating between the various types of soil-release finishes and levels of treatments being investigated. Consequently, in place of the standard polyester-soil fabrics, the same graphite motor oil stain used in the soil-release testing was investigated. Five drops of Arco Graphite Multi-Grade Motor Oil were placed in Launder-Ometer cans containing 200 ml of water and 30 steel balls. The Launder-Ometer was run for 30 minutes at 130°F (54°C). The samples were removed from the cans and individually rinsed in plain, cold (room temperature) tap water for 3 minutes. The amount of redeposition on the white test fabric was then measured with an AATCC Gray Scale for Staining.

All three soil-release finishes, Zelcon 4951, FC-258, and Milease HPA, showed anti-soil redeposition properties. Also, as previously stated, excellent anti-redeposition properties were obtained with the treated fabric that was subjected to 50 shipboard launderings.

EFFECTS OF SOIL-RELEASE TREATMENT

There were no adverse effects from the soil-release treatment on any of the physical and chemical properties of the treated fabric, e.g., tensile and tear strength, dimensional stability, and colorfastness to perspiration, laundering, and seawater. The treatment did impart a slight yellowing to the fabric, but when it was subsequently exposed to Xenon and Carbon-Arc lightfastness tests, the fabric returned to the initial white shade after approximately 40 hours exposure. This slight yellowing, however, is not considered serious, because the shade still falls within the shade tolerance range.

CARE LABELING

Based on the results of this study, it is recommended that the garment care label include the following instructions so as to obtain the most benefit from the soil-release finish.

For Home Laundering

1. The garment should be machine laundered, using a "hot" water temperature setting.
2. A heavy-duty soap or laundry detergent should be used.
3. All stains should be prespotted with a commercial laundry stain pre-treatment.
4. The garment should be tumble-dried (low heat) and removed promptly after drying.

For Drycleaning

It is very important to prespot all stains prior to drycleaning. If this is not done, certain stains, especially water-based stains (juice, etc.) will not be removed. Also, certain oil-based stains (motor oil) might migrate on the fabric. As a result, all stains should be pointed out to the drycleaner before the garment is drycleaned.

DEVELOPMENT OF A SOIL-RELEASE TEST PROCEDURE

To assure that material procured in the future for fabrication into garments will meet the Navy's soil-release performance requirements, we developed a new soil-release test procedure and evaluation method as part of the CNT material specification.

AATCC Test Method 130-1977 was examined as a potential candidate and found unsuitable, since untreated CNT could pass this test. As a result, various test methods being used by industry were evaluated for potential Navy use. After many trials, we found that a combination of AATCC Test Method 130-1981 and AATCC Test Method 61-1980, with slight modifications to each, would provide the desired degree of severity and reproducibility. To eliminate soil redeposition onto the fabric sample through the use of a black motor oil as the staining substance, it was necessary to specify staining the sample with only three drops of the ARCO motor oil and the use of a 500 ml liquid volume. Appendix A contains the complete test procedure.

The AATCC Stain-Release Replicas were also found to be unsuitable for our purposes, because they are based on evaluating a sample that is stained with Nujol brand mineral oil, which is light in color, whereas the NCTR test method calls for staining the sample with Arco graphite motor oil, which is black. As a result, the NCTR Stain-Release Scale (Figure 1) was developed to evaluate the samples. The scale consists of a series of numbers, 1 to 5, where a "1" rating is a heavy stain (worst case), and the progressively higher numbers reflect lesser degrees of staining, up to a "5" which reflects no stain (best case).

The new NCTR Soil-Release Test Method and Stain-Release Rating Scale were developed initially through extensive intralaboratory testing and subsequently through interlaboratory testing in an effort to determine whether both interlaboratory and intralaboratory reproducibility were possible. We performed the intralaboratory study by selecting eight NCTR personnel to perform the NCTR soil-release Test Procedure. Twelve NCTR personnel, including the eight who had originally performed the test, were subsequently asked to evaluate the samples. The interlaboratory evaluation included two of the three soil-release finish suppliers of the CNT fabric (ICI did not participate), four of the fabric suppliers, the Defense Personnel Support Center (DPSC), and the U.S. Army Natick Research and Development Center (NRDC).

NCTRf STAIN-RELEASE RATING SCALE

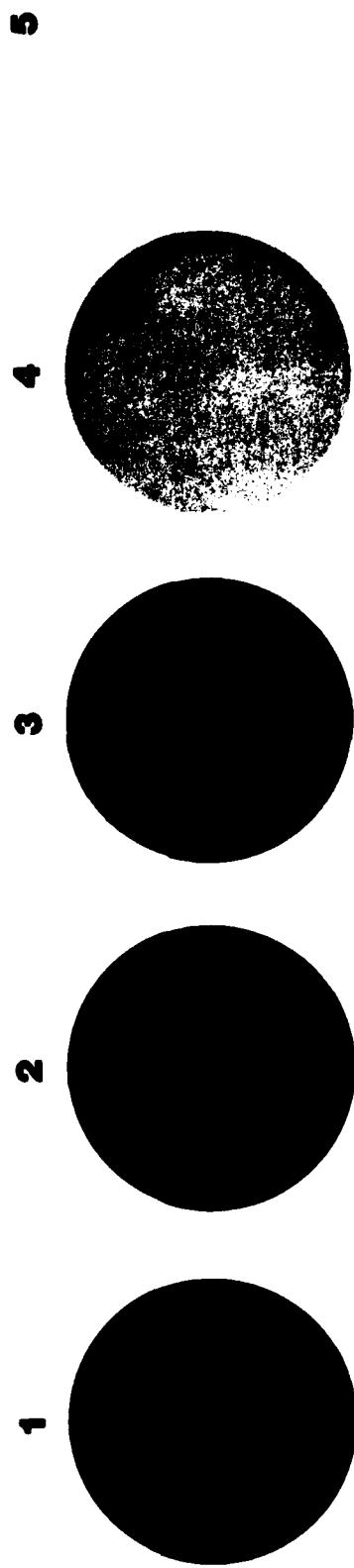


Figure 1. Editor's Note: Because of the offset process used to print this report, the stains in this figure are not exact reproductions of the stains in the NCTRf rating scale. Therefore, this figure should not be used as a substitute for the official NCTRf Stain-Release Rating Scale.

Results of the evaluations are depicted in Figures 2, 3, 4, and 5. Figures 2 and 3 plot the total number of responses each rating scale number received. For example, the first bar in Figure 2 indicates that a "3.5" rating was given to three of the 36 evaluated samples, while a "4.0" rating was given to 15 of the 36 evaluated samples.

Based on the results provided in Figures 2 and 3, Figure 4 shows that industry's ratings appear to be somewhat lower than NCTR's. In Figure 5, however, where industry's ratings are combined into one average rating by adding all of the individual ratings and dividing by the number of responses, the average ratings ranged from "3.5" to "4.1," which is well within the Navy's minimum acceptability limit ("3.0" rating). Upon examination of the swatches that were returned by all laboratories involved, the differences in rating can be mostly attributed to performance of the test method rather than the rating method.

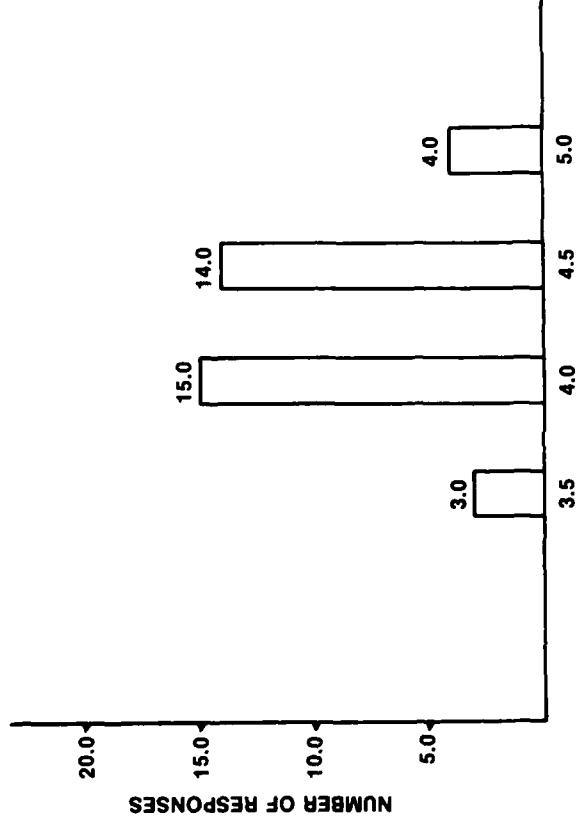


Figure 2. NCTR Stain-release Ratings Based on 36 Evaluated CNT Samples

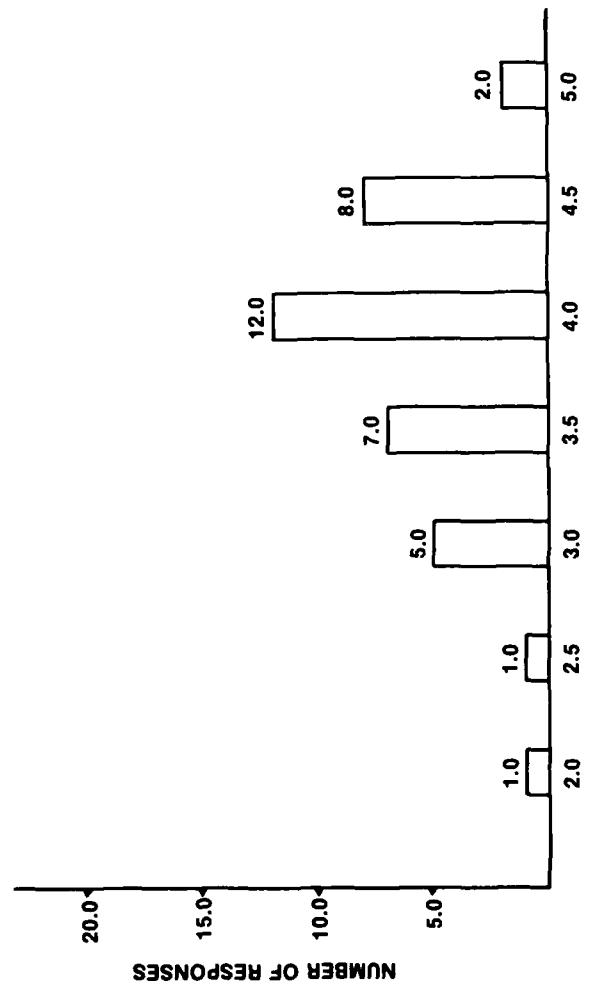


Figure 3. Industry Stain-release Ratings Based on 36 Evaluated CNT Samples

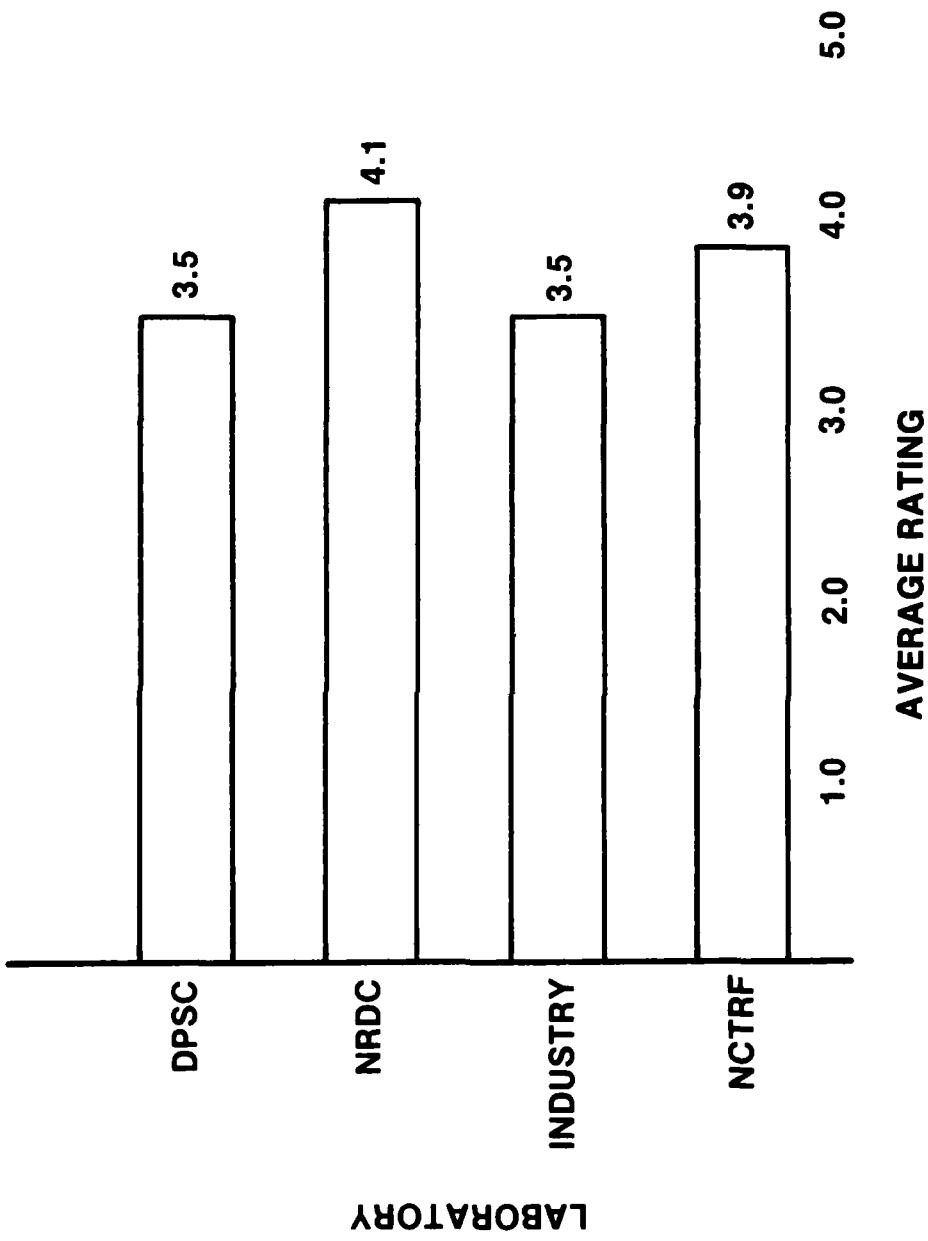


Figure 5. Comparison of Interlaboratory Ratings

CONCLUSIONS

The three polyester soil-release finishes, Zelcon 4951 (DuPont), Scotch-Release Brand FC-258 (3M Co.), and Milease HPA (ICI) were the best commercially available ones that could effectively assist in the control of soil redeposition and in the removal of such stains as black shoe polish, dirty motor oil, fruit juices, and lipstick from the CNT uniforms. These finishes are non-toxic, have no adverse effect on the physical or chemical properties of the fabric, and are durable against multiple home and shipboard launderings and drycleanings.

Based on overall performance, the Zelcon 4951 was judged the best, followed by the FC-258, and the Milease HPA. All three finishes performed significantly better when applied under pressure as opposed to atmospherically.

In comparison with the unfinished CNT material, the soil-release-treated material was 90% more effective in stain removal, with the exception of black shoe polish, for up to 50 shipboard or commercial launderings and 10 dry-cleanings. The removal of black shoe polish is less effective after 10 launderings, but continues to be significantly better than for the untreated fabric. Any of the three selected finishes will easily remove salad dressing and grape juice stains.

The amount of detergent recommended by the manufacturer is a good guide for obtaining optimum soil-release results. Too little or too much detergent will produce unsatisfactory results.

In order to obtain maximum benefit from the soil-release treatment, the washwater should be 140°F (60°C) or higher. Regardless of wash water temperature, a treated fabric can be cleaned more easily than an untreated one.

The use of prespotting laundry products was a very beneficial aid in removing stains during laundering, both on untreated and soil-release-treated CNT. The prespotting products worked better, however, on the soil-release-treated CNT.

RECOMMENDATIONS

Based upon the results of this study, the use of a polyester-type soil-release finish on the CNT fabric is highly recommended. The finish should be applied under pressure, using the manufacturer's recommended application parameters.

Because some of the stains applied to the CNT were not fully removed after laundering or drycleaning, we recommend that a prespotting chemical be applied to the stains, particularly prior to drycleaning. Consequently, it is necessary that an individual point out the location and type of stain to the drycleaner so that it may be properly pretreated. Any graying or yellowing of the garment which resulted from drycleaning can normally be removed by subsequent laundering.

Should a stain not be fully removed during laundering, the garment should be re-laundered prior to drying in order to avoid "setting" of the stain into the fabric. Home launderings should be performed at a minimum temperature of 140°F, or at least at the washer's "hot" water setting, using the amount of detergent recommended by the manufacturer.

For quality assurance purposes, the CNT material specification should state that, when subjected to the NCTR^F Soil-Release Test, samples must attain an average soil-release rating of not less than 3.0 on the NCTR^F Stain-Release Rating Scale.

APPENDIX A. SOIL-RELEASE TEST PROCEDURE

Use three test specimens (4 in x 8 in) for each determination.

Staining

The staining of the test specimens shall be performed in accordance with AATCC T.M. 130-1981, with the following exceptions:

1. The test specimen shall be 4 in. x 8 in.
2. Three drops of ARCO Graphite Multi-Grade Motor Oil (SAE 10W-40) shall be used instead of five drops of the mineral oil (GFM).

Laundering

The laundering of the test specimens shall be performed in accordance with AATCC T.M. 61-1980, Test No. IIIA, with the following exceptions:

1. The total liquor volume shall be 500 ml.
2. Fifteen grams per liter of AATCC (124 WOB) detergent shall be used.
3. A total of 50 stainless steel balls shall be used.
4. No multi-fiber test fabric or bleached cotton fabric is required.
5. At the end of the cycle, rinse in running water at 105°F for 5 minutes. No souring is required.
6. Hydroextract the test specimens to remove excess moisture. Air dry or oven dry at 220°F.

Evaluation

The test specimens shall be evaluated in accordance with the AATCC T.M. 130-1981 procedure, except that the NCTR test stain-release replica shall be used (GFM). The treated specimens shall have an average soil-release rating of not less than 3.0 when tested as specified.

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